RF Power Upgrade for CEBAF at the Jefferson Laboratory

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THOCS4

CEBAF (circa 2010)

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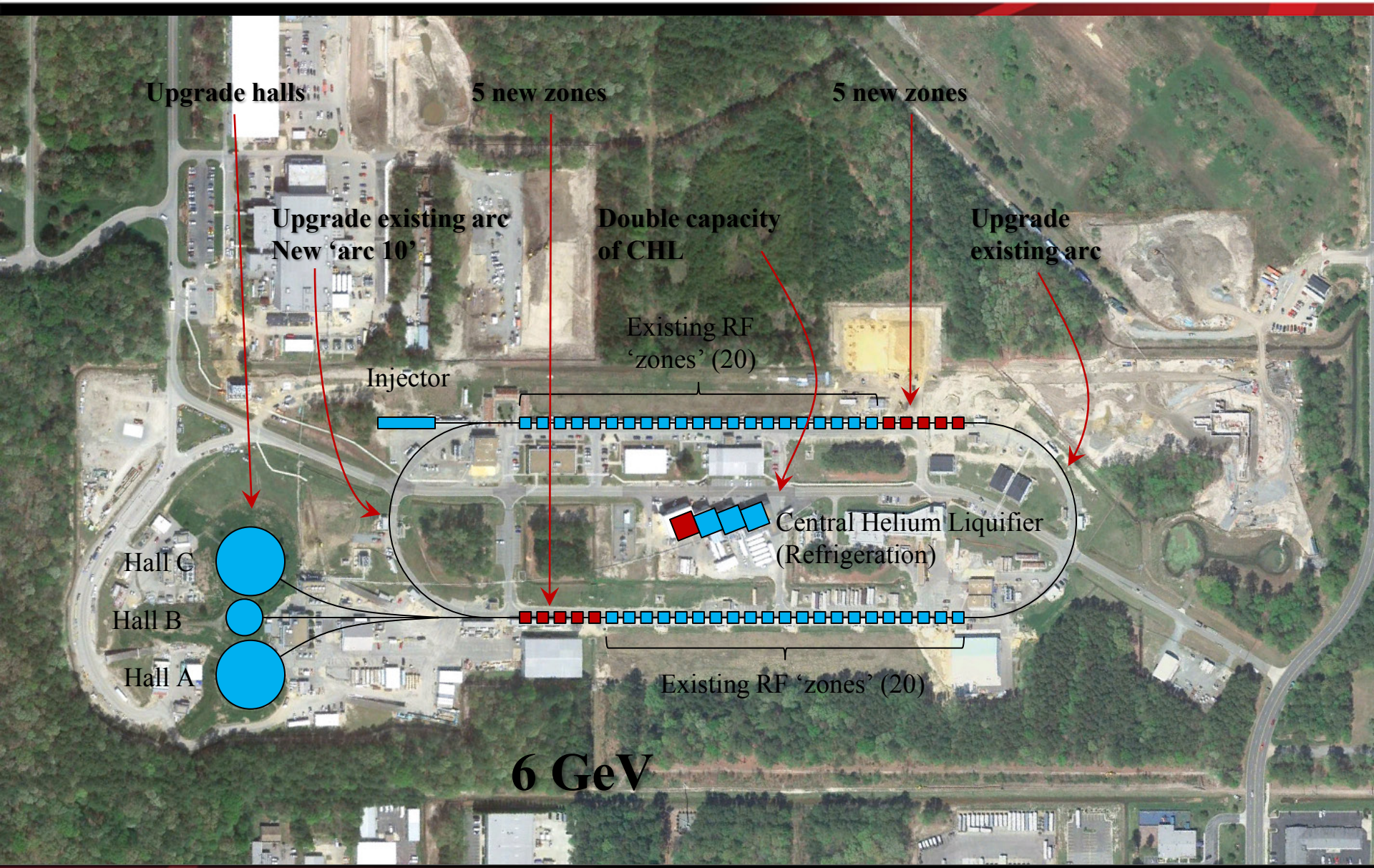
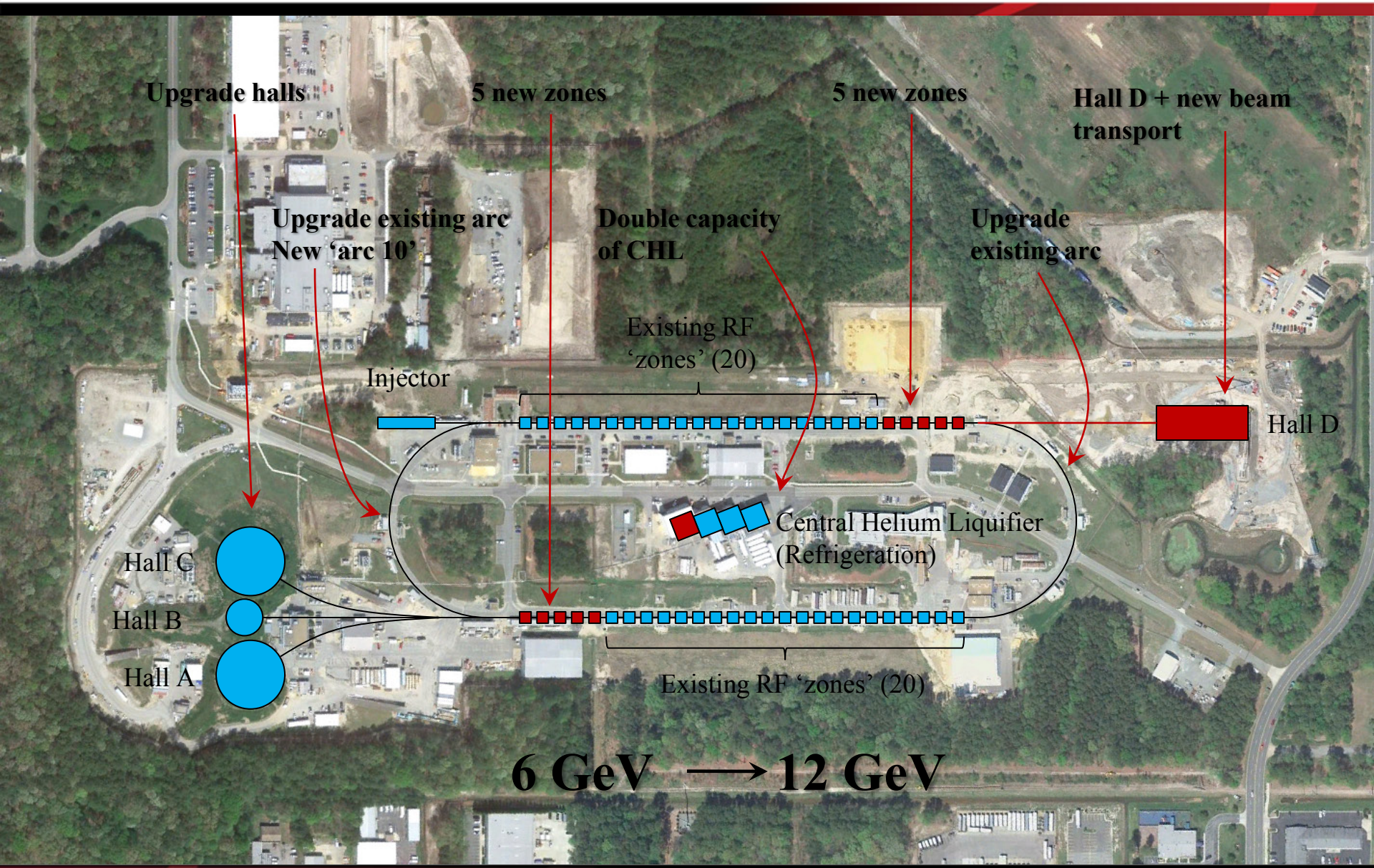
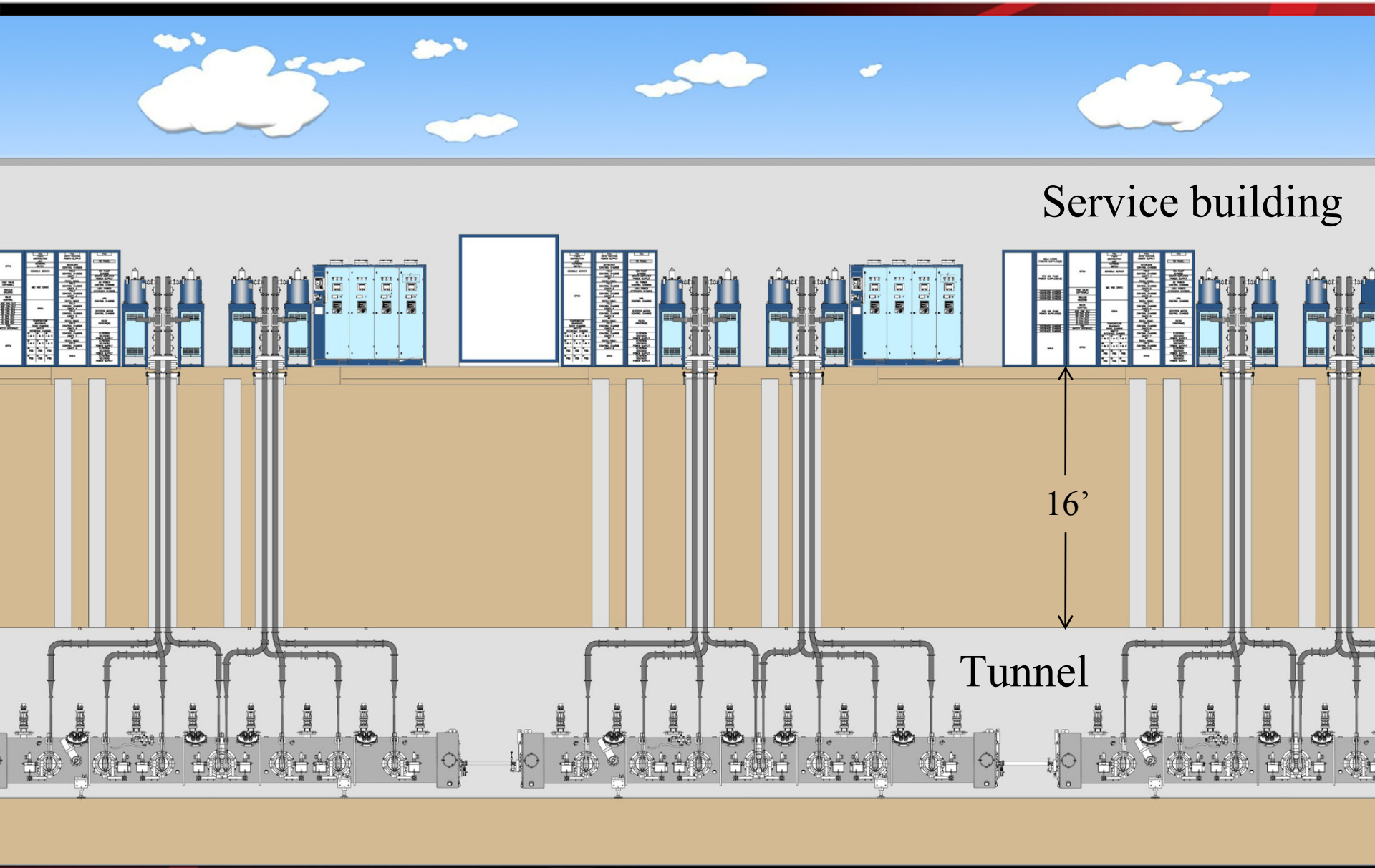


CEBAF (circa 2013)



Section view



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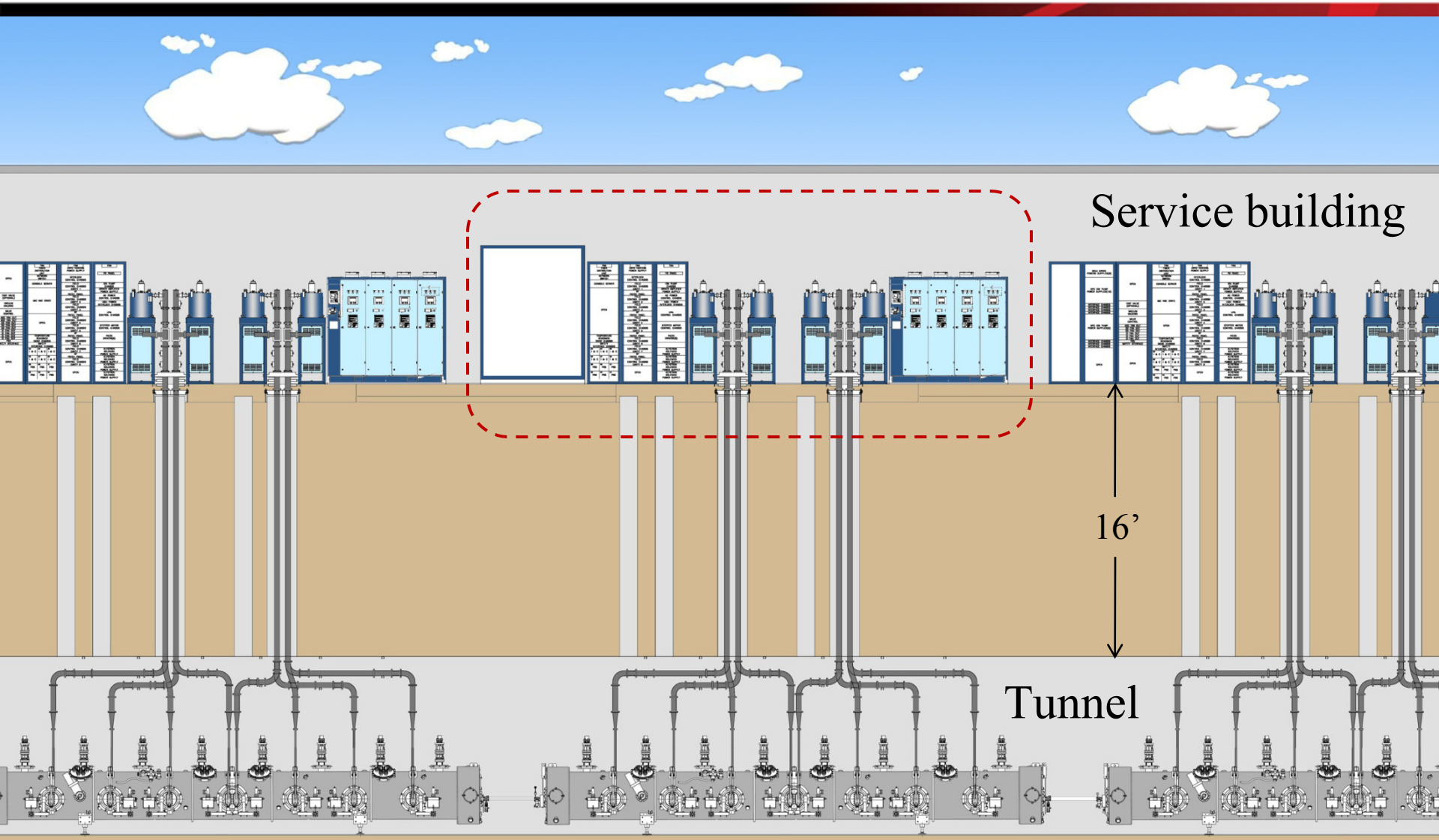


Major RF changes

- Add ten ‘C100’ cryomodules (8 x 7 cell cavities, 100 MeV acceleration per cryomodule)
- Ten new RF systems
  - Includes new designs for high power and low level elements
  - New high power RF source needed to provide 13kW CW to each cavity @ 1.497Ghz
  - New high voltage DC power supplies
  - Waveguide components (isolators, couplers, tuners, HOM filters… mostly new designs)
  - Mechanical assemblies, water manifolds, etc.

Tube or solid state?

Solid state:

- Cost of development? Size?
- Transistors go obsolete quickly, drop in replacements unlikely.

IOT:

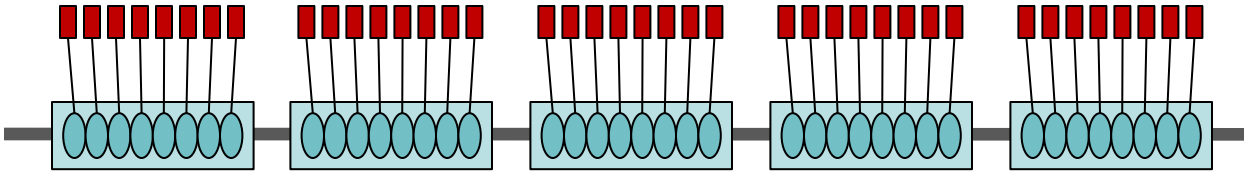
- Better efficiency than a klystron, but lower gain therefore a more expensive pre-amp needed.
- Reliability of non-UHF IOT?
- Not built at 1.5GHz, limited history other than UHF
- Cost of IOT higher than klystron

Klystron:

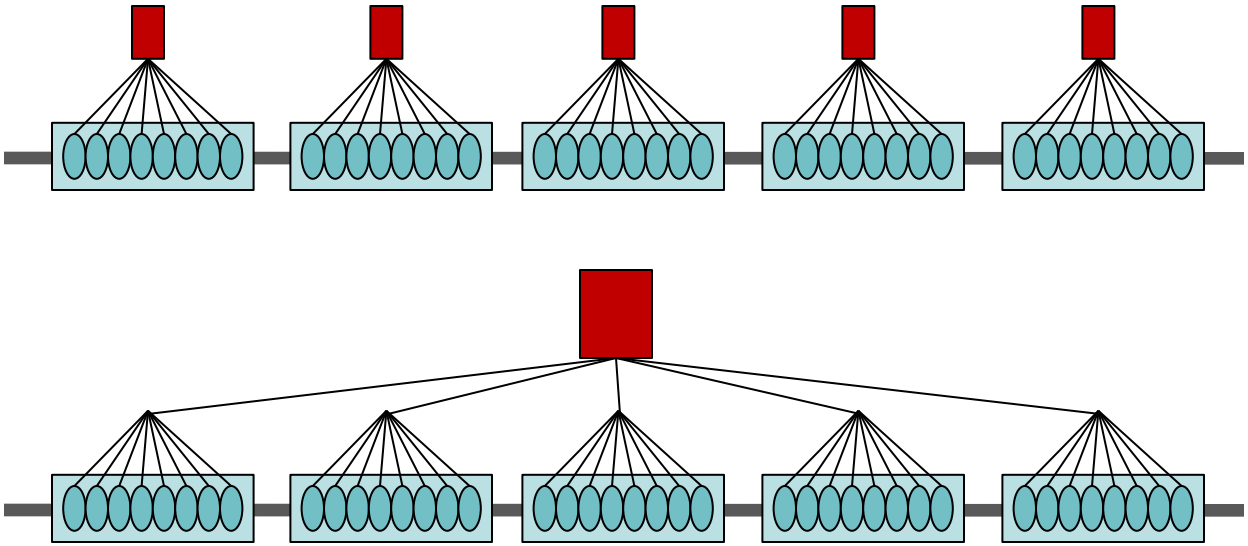
- Current 5kW design reliable (average >150k hours as of 2008)
- Common design elements (same gun), backwards compatibility of power supplies (with slight modification)
  - Filament and Mod Anode power supplies

How many sources of RF?

1 per cavity
(current system)
Minimum impact of failures

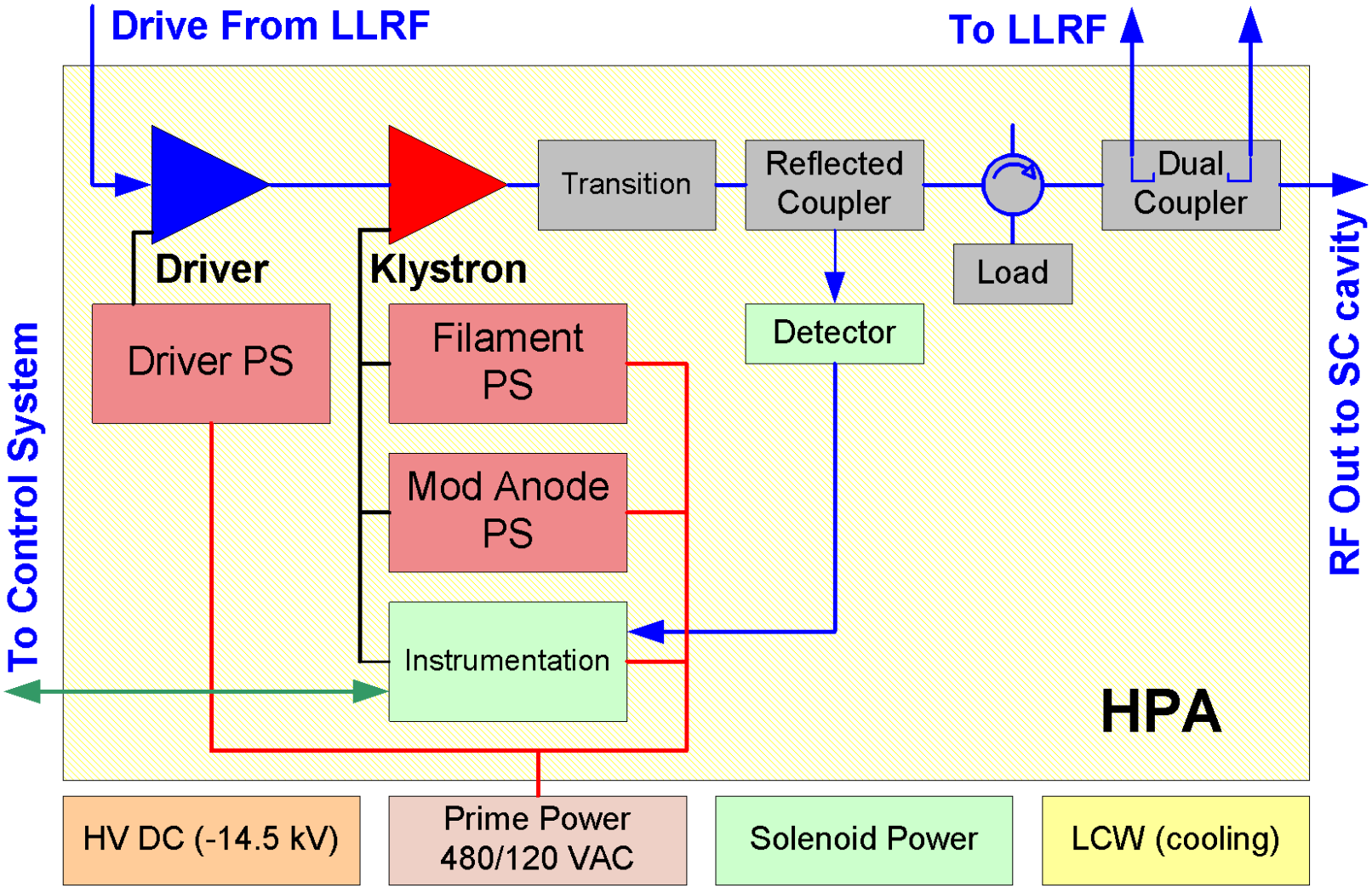


1 per zone/linac
Larger impact
High power splitters
Amplitude and phase regulated to high precision.



Additional controls and high power modulator found to be more $$$ than individual RF sources.

RF System overview

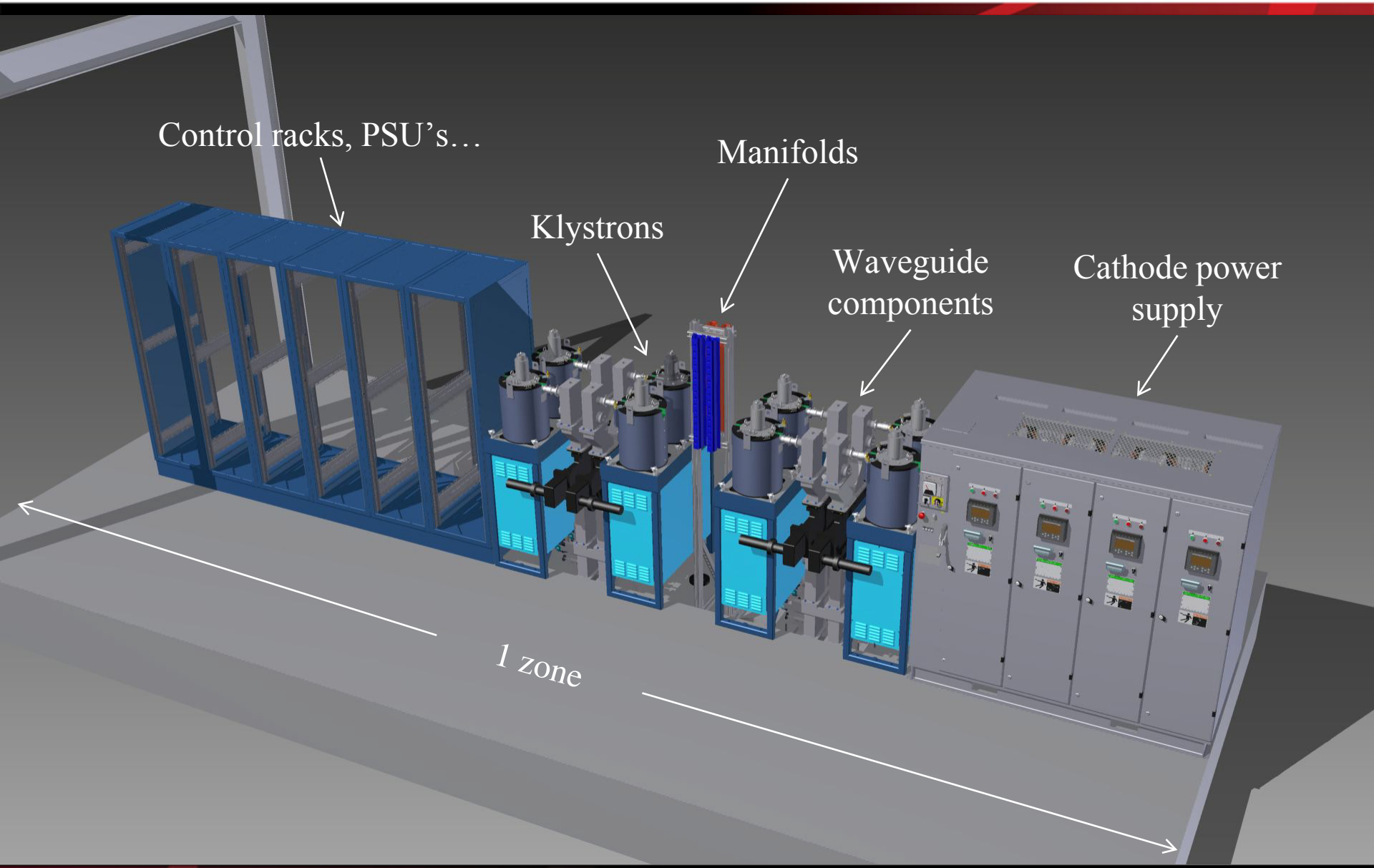


Challenges

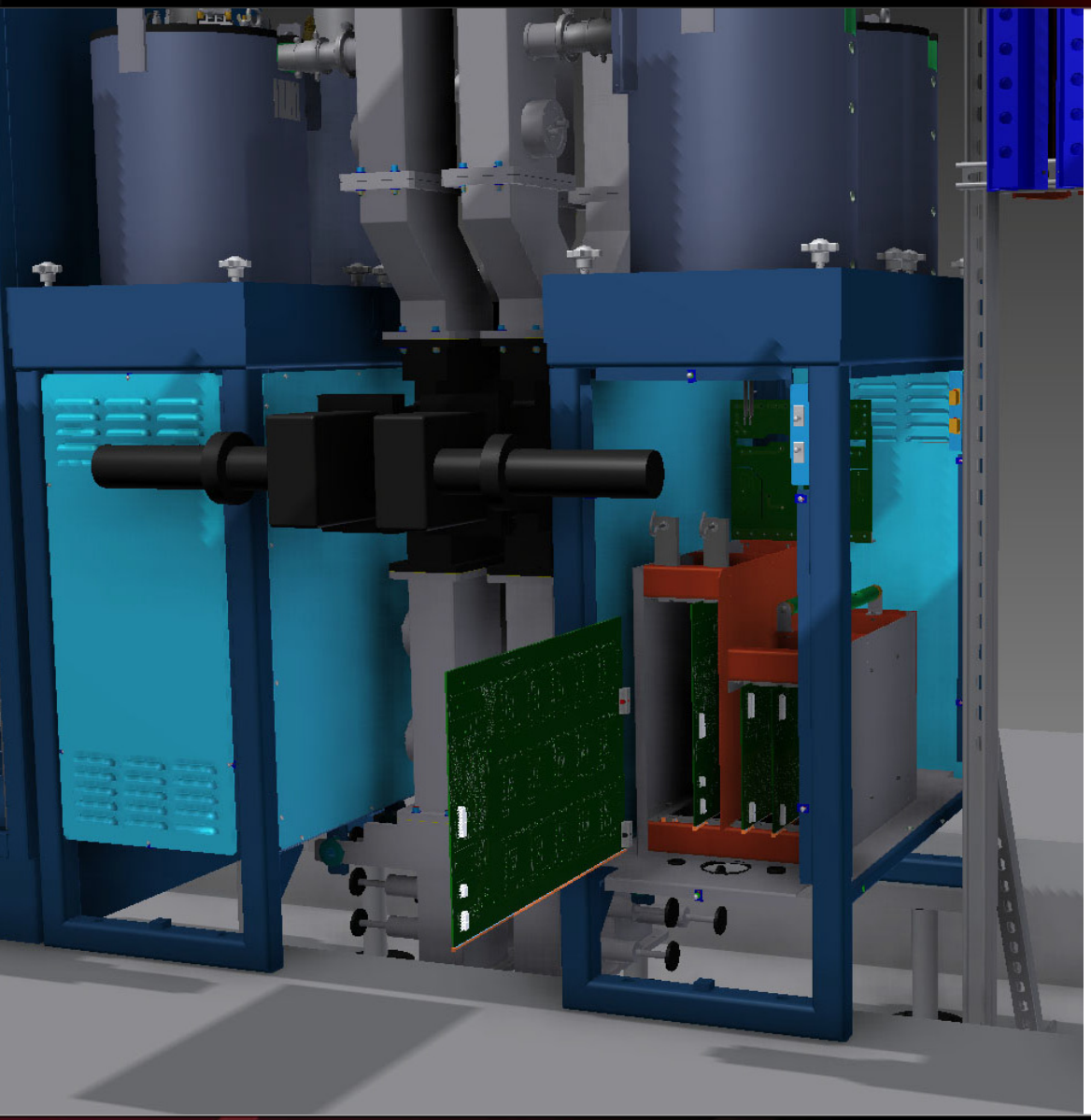
- New equipment must fit into existing space
- CEBAF was originally conceived as a 4 pass/25 zone per linac machine at 4GeV
- Built as a 5 pass/20 zone per linac machine to save money
- Linac buildings and tunnel were built for 25 zones
- Upgrade will fill empty slots

- New RF must fit the same footprint
- Larger klystrons, larger DC power supply, …

Planned layout



Auxiliary power supplies



Klystron Requirements

Parameter	Old req	New req	Actual value	Units
Power	5 & 8	13	13	KW
Center frequency	1497	1497		MHz
Bandwidth, -1dB	5	5		MHz
Bandwidth, -3 dB	6	6		MHz
0.5 dB incremental gain at	4	10		kW
Efficiency (at rated power)	32	>50	50.9	%
Gain	38	>42		dB
Harmonics	-20	-20		dBc
Beam voltage	11.6	<16	14.5	kV DC
Heater voltage	7.3	7.3	7.0	V DC
Modulating anode	Yes	Yes		
Isolated collector	Yes	Yes		
Cavities	4	5		
Focus magnet	PM	EM	873	Watts

225kW DC power supply

- Used to power klystron cathode
- Resonant mode switcher
- 4 separate supplies, each powering 2 klystrons
  - One can trip, remainder stay on
- Voltage adjustable to -15kV @ 3.75A (15A total)
- Supply has origins in electrostatic precipitators, 1000+ units in the field
- Low stored energy
- Quick turn off in event of arc
- No crowbar required
- Good diagnostics

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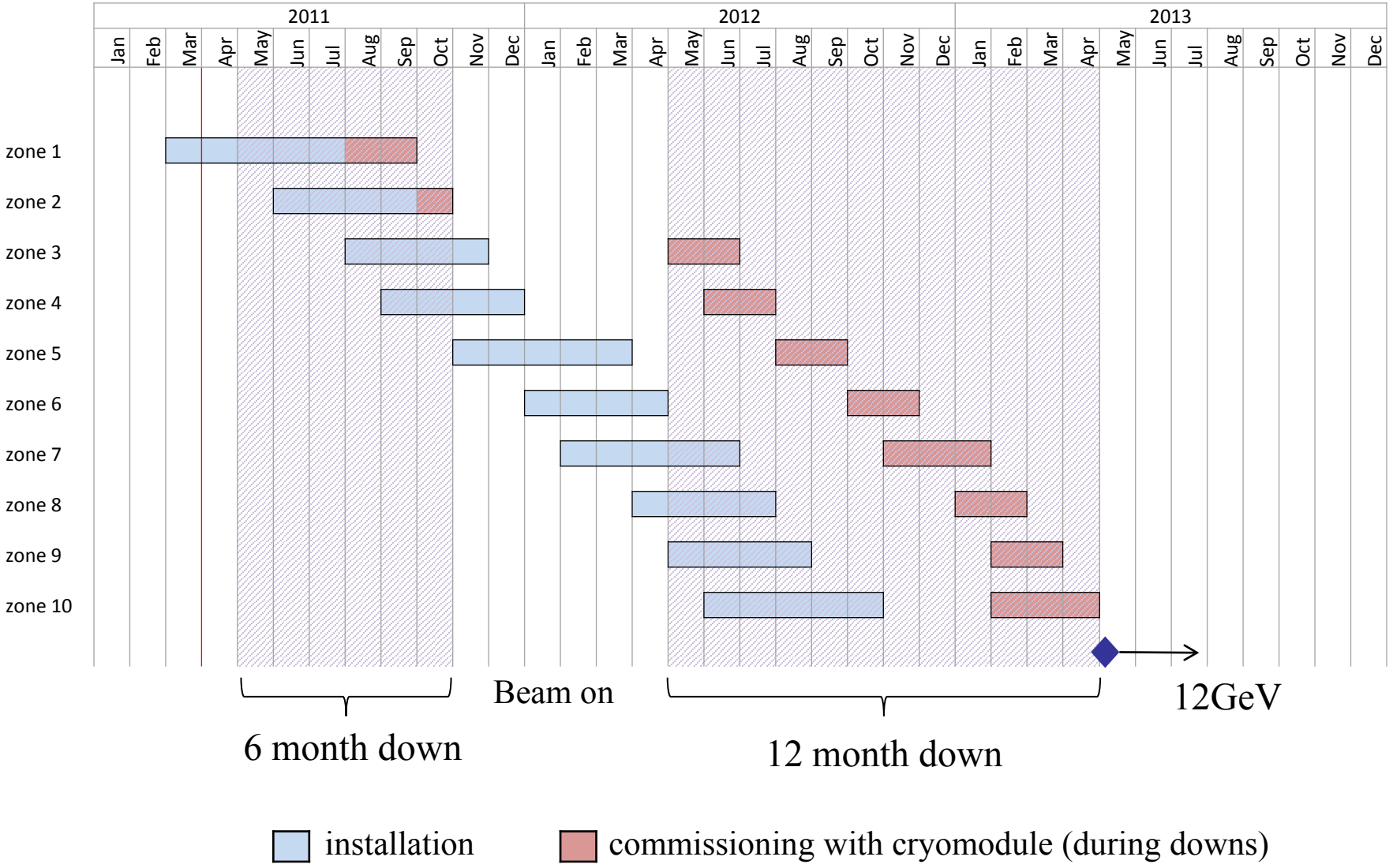
RF Schedule


2011
2012
2013
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
zone 1
zone 2
zone 3
zone 4
zone 5
zone 6
zone 7
zone 8
zone 9
zone 10
Beam on
12GeV
6 month down
12 month down
installation
commissioning with cryomodule (during downs)

Current status (as of March 2011…)

- First article Klystron in house and being tested
- First article cathode power supply in house and installed
- Isolators all in house and awaiting installation
- Waveguide contract awarded, first delivery in April
- HOM filter first article due in June
- Mechanical assemblies all in house, awaiting installation
- Solenoid power supply first article due late March
- Filament PSU's, Mod anode PSU's tested and awaiting installation
- Interface boards ordered, awaiting delivery
- Most cables and connectors ordered, awaiting delivery